MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2019 / 2020

ECE3296 – DIGITAL IMAGE AND VIDEO PROCESSING

(CE)

14 OCTOBER 2019
2.30 p.m. - 4.30 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of **EIGHT** printed pages with **FOUR** questions.
2. Answer **ALL** questions.
3. Write your answers in the Answer Booklet.

Question 1

(a) Given two images $f(x, y)$ and $g(x, y)$, discuss briefly how the following arithmetic operations can be used in image and video processing applications:

i. Addition
ii. Subtraction
iii. Multiplication
iv. Division

[6 marks]

(b) Geometrical image transformation can be represented by a 3×3 transformation matrix T, given in the equation below:

$$\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = T \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$

Deduce the matrix T for the following geometrical transformations:

(i) Translated 3 units to the left and 5 units down.

[2 marks]

(ii) Rotated 45° counter-clockwise and scaled down by half, both horizontally and vertically.

[4 marks]

(iii) Vertical and horizontal shearing by a factor of 0.8 and 1.2 respectively.

[2 marks]

(c) Write the equations for the Euclidean, city block and chess board distances for 2D image processing. Explain the reason why the city-block distance and chess board distance metrics are preferable compared to the Euclidean distance in image and video processing applications.

[5 marks]

(d) Figure Q1 shows several intensity transformation techniques commonly used in image enhancement by point processing. Let $L = 256$, explain output of the Log and Inverse Log intensity transformations. Use a table to illustrate the mapping of several input and output gray levels.

[6 marks]

Continued ....

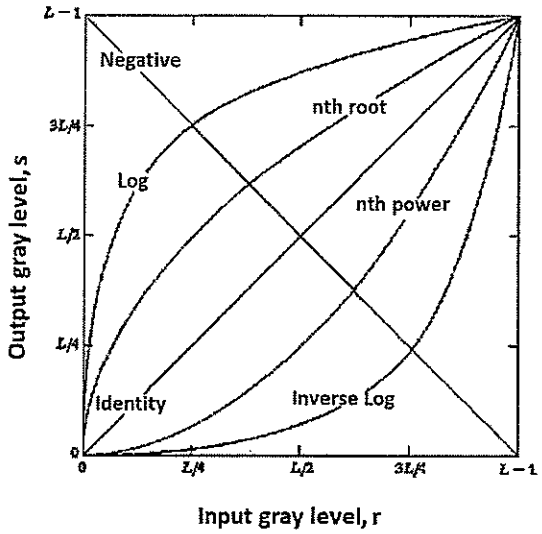

Figure Q1

Question 2

(a) Explain the difference between image enhancement and image restoration.

[4 marks]

(b) Figure Q2(a) shows a 7x7 image. Most of the pixels are dark pixels, except for small blob of 5 pixels in the shaded area which constitutes bright pixels (noise).

50	49	48	49	50	50	51
49	48	47	47	48	49	49
50	49	48	47	47	48	49
49	49	49	48	48	47	48
51	52	53	200	201	202	47
50	51	52	199	200	47	46
50	50	51	50	49	48	47

Figure Q2(a)

Continued ....

(i) Suggest what would happen to the noise if the image is filtered with the following smoothing filters:

- 3×3 averaging filter
- 5×5 averaging filter
- 3×3 median filter
- 5×5 median filter

Provide your suggestions based on theoretical argument. You do not need to compute the filtered pixel values of the image.

[4 marks]

(ii) Which of the above filter in (i) would produce the best result in removing the noise? Compute the filtered output of the pixels in the shaded area for the filter you selected.

[4 marks]

(c) Figure Q2(b) shows a mask approximation of a Mexican Hat filter.

0	0	-1	0	0
0	-1	-2	-1	0
-1	-2	16	-2	-1
0	-1	-2	-1	0
0	0	-1	0	0

Figure Q2(b)

i. Determine the types of this filter. Provide justification to your answer.

ii. Describe the output generated by applying this filter to a digital image.

iii. What is the relation between this filter and the Laplacian of Gaussian filter (LoG)?

[5 marks]

(d) Describe the four techniques commonly used in image restoration. Highlight the differences/uniqueness of each technique.

[8 marks]

Continued ....

Question 3

(a) Figure Q3(a) shows the initial results of two different region-based segmentation processes (left) together with the final result after post-processing (right). For each segmentation result, discuss the post-processing operations involved.

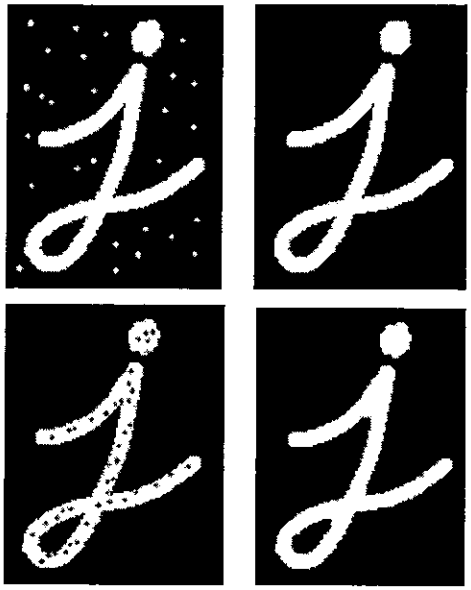

Figure Q3(a)

[4 marks]

(b) Figure Q3(b) shows a 7 × 7 image, together with a Prewitt edge detector.

200	200	200	200	50	50	50
200	200	200	200	50	50	50
200	200	200	200	50	50	50
200	200	200	200	50	50	50
50	50	50	50	50	50	50
50	50	50	50	50	50	50
50	50	50	50	50	50	50

Image

-1	-1	-1
0	0	0
1	1	1

-1	0	1
-1	0	1
-1	0	1

Prewitt Edge Detector

Figure Q3(b)

Continued...

(i) Using the Prewitt operator mask, detect the horizontal edge, g_x and vertical edge g_y in the image in Figure Q3(b).

[4 marks]

(ii) Based on the g_x and g_y obtained in (i), determine the magnitude and direction of the detected edges.

Use $magnitude = |g_x| + |g_y|$ and $direction = 90 - tan^{-1}\left(\frac{g_x}{g_y}\right)$

Only compute the non-zero entries.

[4 marks]

(iii) Suggest a suitable threshold to detect the lines for this particular image.

[2 marks]

(iv) Comment on the direction of edges obtained in (ii). Does it make sense?

[2 marks]

(v) Based on the above, state one advantage of gradient filter compared to Laplacian filter.

[1 mark]

(c) Figure Q3(c) shows an RGB color model commonly used in image processing and analysis.

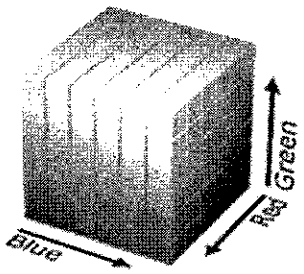

Figure Q3(c)

(i) By using 8-bin histogram as an example, explain how 3D RGB color histogram can be used as features in image representation.

[5 marks]

(ii) One shortcoming of color histogram is that it does not incorporate any spatial information in the feature. Discuss how can this be addressed.

[3 marks]

Continued...

Question 4

(a) Figure Q4(a) shows 3 different classes of image patterns, with 4 different samples per pattern (one pattern occupy one row of images). As a computer programmer, you are required to design and develop a program that can classify the 12 images into the 3 different classes. Include your hypotheses and description of the methods that can be used for each step in the system, from pre-processing to recognition.

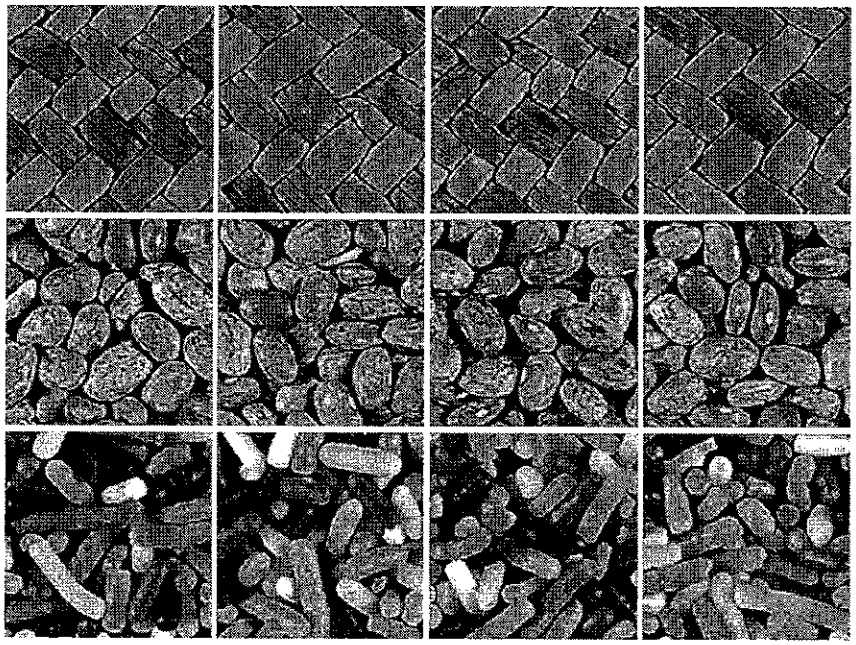

Figure Q4(a)

[10 marks]

(b) Consider a high definition TV (HDTV) with 1125 horizontal lines and the picture aspect ratio (width-to-height) of 16:9. Suppose we would like to digitize the video using the following parameters:

- The horizontal-to-vertical resolution ratio is similar to picture aspect ratio.
- The video is sampled at 30 frames per second
- Each color components (R, G, B) of a pixel is encoded with 8 bits.

(i) Compute the raw size, in TB, of a 2-hour video program for this format.

[4 marks]

(ii) Suggest 3 ways to compress the size of the video.

[3 marks]

Continued...

(c)

Figure Q4(b)

Figure Q4(b) shows a video sequence of a golf swing. Suppose the current video sampling rate is 15 frames per second.

Propose how you would design a system to increase the video sampling rate. Please provide the justification on methods that you have chosen.

[8 marks]

End of paper